(19) Europäisches Pat ntamt
European Patent Office
Office europóen d s br vets

(11) Publication number: 0 611 683 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(21) Application number: 93919663.0

(51) Int. Cl.5: B60R 21/16

(22) Date of filing: 14.09.93

(86) International application number:
PCT/JP93/01315

(87) International publication number:
WO 94/06652 (31.03.94 94/08)

(30) Priority: 14.09.92 JP 269149/92

(43) Date of publication of application:
24.08.94 Bulletin 94/34

(84) Designated Contracting States:
DE FR GB IT

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(54) AIR BAG WITH REINFORCING BELTS.

(57) An air bag with reinforcing belts having high burst strength and superior safety comprising a circular top cloth (1), a circular bottom cloth (2) sewn to said circular top cloth and having an inflator mounting circular hole at its central portion, top and bottom reinforcing cloth pieces (5), (6) sewn to the central portions of said top and bottom cloth, respectively, and a plurality of reinforcing belts (7) disposed on the internal sides of said top and bottom cloths, wherein one ends of said reinforcing belts are connected to a top belt catcher (17) sewn to said top reinforcing cloth piece or said top cloth, wherein the other ends of said renforced belts is connected to a bottom belt catcher (18) sewn to said bottom reinforcing cloth piece or said bottom cloth, and wherein said top cloth and said bottom cloth are sewn, respectively, to their corresponding reinforcing cloth and, if required, to their corresponding belt catcher along a concentric closing sewing line and satisfies the following relation (I): $0.45 \leq \Phi/L \leq 2.95$ [where Φ is the shortest straight distance between two intersection points at which a line passing through the center of said circular top or bottom cloth intersects the outermost circumference of said sewing line, and L is a straight distance from an intersection point between the longitudinal central axis of said reinforcing belt and the outermost circumferential sewing line of said top reinforcing cloth piece to an intersection point between the longitudinal central axis of said reinforced belt and the outermost circumferential sewing line of said bottom reinforcing cloth piece.]

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a closed outermost circumferential seam line of at least one of the top and bottom reinforcing clothes and each of the reinforcing belts satisfy the relationship (I):

$$0.45 \leq \phi/L \leq 2.95 \qquad (I)$$

wherein, ϕ represents a shortest straight line distance between two points at which a straight line drawn through a center of at least one of the circular top and bottom cloths, having the closed outermost circumferential seam line, intersects the outermost circumferential closed seam line, and L represents a straight line distance between an intersecting point of a longitudinal center line of the reinforcing belt with the outermost circumferential closed seam line of the top reinforcing cloth and an intersecting point of the longitudinal center line of the reinforcing belt with the outermost circumferential closed seam line of the bottom reinforcing cloth, measured along the longitudinal center line.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is an explanatory view of an inside face of a top cloth of an embodiment of a conventional air bag provided with reinforcing belts, when turned inside out before being inflated,

Fig. 1B is an explanatory view of an inside face of a bottom cloth of the conventional air bag of Fig. 1A turned inside out,

Fig. 1C is an explanatory cross-section of the conventional air bag of Figs. 1A and 1B when inflated, showing arrangements and seam-joints of reinforcing clothes and reinforcing belts,

Fig. 2A is an explanatory view of an inside face of a top cloth of an embodiment of the air bag of the present invention provided with reinforcing belts, when turned inside out before being inflated,

Fig. 2B is an explanatory view of an inside face of a bottom cloth of the air bag of Fig. 2A, when turned inside out,

Fig. 2C is an explanatory cross-section of the air bag of Figs. 2A and 2B, when inflated, showing arrangements and seam joints of reinforcing clothes and reinforcing belts,

Fig. 3A is an explanatory view of an inside face of a top cloth of another embodiment of the air bag of the present invention provided with reinforcing belts, when turned inside out before being inflated,

Fig. 3B is an explanatory view of an inside face of a bottom cloth of the air bag of Fig. 3A, when turned inside out,

Fig. 3C is an explanatory cross-section of the air bag of Figs. 3A and 3B, when inflated, showing arrangements and seam joints of reinforcing cloths and reinforcing belts,

Fig. 4A is an explanatory view of an inside face of a top cloth of still another embodiment of the air bag of the present invention provided with reinforcing belts, when turned inside out before being inflated,

Fig. 4B is an explanatory view of an inside face of a bottom cloth of the air bag of Fig. 4A, when turned inside out,

Fig. 5A is an explanatory view of inside face of a top cloth of still another embodiment of the air bag of the present invention provided with reinforcing belts, when turned inside out before being inflated,

Fig. 5B is an explanatory view of an inside face of a bottom cloth of the air bag of Fig. 5A, when turned inside out,

Fig. 5C is an explanatory cross-section of the air bag of Figs. 5A and 5B, when inflated, showing arrangements and seam joints of reinforcing cloths and reinforcing belts,

Fig. 6A is an explanatory view of an inside face of a top cloth of further another embodiment of the air bag of the present invention provided with reinforcing belts, when turned inside out before being inflated,

Fig. 6B is an explanatory view of an inside face of a bottom cloth of the air bag of Fig. 6A, when turned inside out,

Fig. 6C is an explanatory cross-section of the air bag of Figs. 6A and 6B, when inflated, showing arrangements and seam joints of reinforcing cloths and reinforcing belts and belt catchers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

To make clear the characteristics in constitution and effects of the air bag of the present invention provided with reinforcing belts, first, a conventional air bag having reinforcing belts will be explained below.

A conventional air bag provided with reinforcing belts, as shown in Figs. 1A, 1B and 1C, comprises a top cloth 1 formed from a woven fabric piece cut into a substantially circular form, and a bottom cloth 2 formed from a woven fabric piece cut into a substantially circular form. The circular top cloth 1 and the circular bottom cloth 2 are superimposed on and seam-joined to each other at circumferential edge portions

3 thereof by a seam line 3a, for example, a double chain stitch seam line.

In a center portion of the circular bottom cloth 2, a circular hole 4 for connecting the cloth 2 to an inflator 4a is formed.

In the center portion of the circular top cloth 1, a top reinforcing cloth 5 consisting of two woven fabric pieces is arranged on and seam-joined to the center portion, in a portion around the inflator-connecting hole 4 of the circular bottom cloth 2, a bottom reinforcing cloth 6 consisting of two woven fabric pieces is arranged on and seam-joined to the portion.

Also, a plurality of, four in Figs. 1A to 1C, reinforcing belts 7 are arranged between the inside face of the circular top cloth 1 and the inside face of the circular bottom cloth 2, and each of the reinforcing belts is made from at least one (one in Fig. C) woven fabric piece.

An end portion of each reinforcing belt is seam-joined to the top reinforcing cloth 8 along a seam line 8, and an opposite end portion of each reinforcing belt is seam-joined to the bottom reinforcing cloth 6 along a seam line 9.

In Fig. 1A, the top cloth 1 is seam-joined to the top reinforcing cloth along concentrically circular multiple seam lines formed around the center 10 of the top cloth 1 and a seam line 11 located in the outermost circumference of the concentrically circular multiple seam lines has a diameter ϕa.

As shown in Fig. 1A, the direction Ka of warp yarns of the woven fabric piece from which the top cloth 1 is formed and the direction Kb of warp yarns of the woven fabric piece from which the top reinforcing cloth 5 is formed are parallel to each other, and the warp directions Kc of the woven fabric pieces from which the reinforcing belts 7 are formed, intersect the directions Ka and Kb at bias angles. By the above-mentioned arrangements, when the air bag is inflated by an inflation gas, the reinforcing belts can exhibit an enhanced reinforcing effect for the air bag.

In Fig. 1B, the bottom cloth 2 is provided with two vent hole 12, and vent hole-reinforcing aprons 13 are seam-joined to portions of the bottom cloth 2 around the vent holes 12. Also, the bottom cloth 2 and bottom reinforcing cloth 6 seam-joined to the bottom cloth 2 are provided with a plurality of holes 14 for inflator-fixing bolts, located around the inflator-connecting hole 4. The bottom cloth 2 and the bottom reinforcing cloth 6 are seam-joined to each other along a plurality of concentrically circular seam lines located around the center 15 of the bottom cloth 2, and an outermost circumferential seam line 16 has a diameter ϕb.

As shown in Fig. 1B, the warp direction Kd of the woven fabric piece from which the bottom cloth 2 is formed and the warp direction Ke of the woven fabric piece from which the bottom reinforcing cloth 6 are intersect each other at a bias angle, and the warp directions Kc of the woven fabric pieces from which the reinforcing belts are formed are parallel to the above-mentioned warp direction Kd and intersect the above-mentioned warp direction Ke at bias angles. Also, the direction of warp or weft yarns of the reinforcing belts 7 is parallel to the longitudinal center lines of the reinforcing belts.

In both the top cloth and the bottom cloth of the conventional air bag, the ratio $\phi a/L$ and the ratio $\phi b/L$ fall outside of the range of from 0.45 to 2.95, and therefore when an inflation gas is blown to inflate the air bag, the air bag is unsatisfactory in the burst strength thereof.

The reinforcing belt-provided air bag of the present invention comprises, in the same way as the conventional air bag as shown in Figs. 1A to 1C, a circular top cloth, a top reinforcing cloth seam-joined to the circular top cloth, a circular bottom cloth, a bottom reinforcing cloth seam-joined to the bottom cloth, a plurality, preferably 3 or more, more preferably 4 or more, of reinforcing belts arranged between the inside face of the circular top cloth and the inside face of the circular bottom cloth.

In an embodiment of the reinforcing belt-provided air bag of the present invention, an end portion of each of the reinforcing belts is connected to the top reinforcing cloth, and an opposite end portion of each of the reinforcing belts is connected to the bottom reinforcing cloth. In this case, the top and bottom reinforcing cloths are respectively superimposed on and seam-joined to the inside faces of the top and bottom cloths.

In another embodiment of the reinforcing belt-provided air bag of the present invention, a top belt catcher and a bottom belt catcher each comprising of at least one woven fabric piece are respectively arranged on and seam-joined to the inside faces of the top and bottom cloths. An end portion of each reinforcing belt is connected to the top belt catcher and an opposite end portion of each reinforcing belt is connected to the bottom belt catcher. In this case, the top and bottom reinforcing cloths may be respectively arranged on and seam-joined to the inside faces of the top and bottom cloths or the outside faces thereof.

The top cloth and the top reinforcing cloth, or the top cloth, top reinforcing cloth and the top belt catcher are seam-joined to each other along a plurality of concentrically closed seam lines located around the center of the top cloth.

The bottom cloth and the bottom reinforcing cloth or the bottom cloth, the bottom reinforcing cloth and the bottom belt catcher are seam-joined to each other along a plurality of concentrically closed seam lines located around the center of the bottom cloth.

In the reinforcing belt-provided air bag of the present invention among the plurality of concentrically closed seam lines formed on at least one of the top reinforcing cloth and the bottom reinforcing cloth, a closed seam line located in the outermost circumference thereof and each reinforcing belt must satisfy the relationship (I):

$0.45 \leq \phi/L \leq 2.95$ (I)

In the relationship (I), ϕ represents a shortest straight line distance between two points at which a straight line drawn through a center of the circular top cloth, or the circular bottom cloth having the closed outermost circumferential seam line, intersects the closed outermost circumferential seam line, and L represents a straight line distance between a point at which a longitudinal center line of the belt intersects the closed outermost circumferential seam line on the top reinforcing cloth and another point at which the longitudinal center line of the belt intersects the closed outermost circumferential seam line of the bottom reinforcing cloth, and measured along the longitudinal center line of the belt.

The reinforcing belt-provided air bag of the present invention satisfying the relationship (I) exhibits an excellent burst strength when inflated by an inflation gas. Namely, generally speaking, when an inflation pressure is applied to an air bag, the burst-starting points of the air bag are concentrated to the closed outermost circumferential seam line portion of the top and/or bottom cloth and the top and/or bottom reinforcing cloth seam-joined thereto, and the burst portions are expanded along the above-mentioned seam line. Also, when inflated, the bursting of the top and bottom cloths by the impact energy of the inflation gas occurs in the center portions thereof. Nevertheless, the reinforcing belt-provided air bag of the present invention satisfying the relationship (I) can absorb the bursting force and the impact energy applied to the closed outermost circumferential seam line with high efficiency and exhibit a significantly enhanced burst strength.

In the above-mentioned relationship (I), when the ratio ϕ/L is less than 0.45, the end portions of the resultant reinforcing belt is respectively connected at locations relatively close to the inflator to the top reinforcing cloth or the top belt catcher and to the bottom reinforcing cloth or the bottom belt catcher, and the value of L is relatively large. Therefore, when the inflation gas is blown into the air bag to inflate the air bag, a bursting stress is concentrically applied to the center portions of the top cloth and the bottom cloth, and thus the air bag exhibits a reduced burst strength. Also, when the ratio ϕ/L is more than 2.95, the two end portions of the resultant reinforcing belt are respectively connected at locations close to the seam lines in the circular circumferential edge portions of the top cloth and the bottom cloth, to the top and bottom reinforcing clothes or the top and bottom belt catchers, and the length of the reinforcing belt becomes relatively short. Therefore, when the inflation gas is introduced into the air bag, the reinforcing belts cannot fully absorb the impact energy of the inflation gas by an elongation of the belts, and as a result, the air bag exhibits an unsatisfactory burst strength.

When the air bag is inflated, the reinforcing belts serve to pull the top cloth and the bottom cloth toward the inside of the air bag in a direction of an approximately right angle to the outermost circumferential closed seam line of the top or bottom reinforcing cloth. Therefore, no tensile stress is generated in the wrap and weft directions of the woven fabric piece from which the top or bottom cloth is formed, and a tensile stress is applied to the warp and weft yarns in radius directions of the yarns. In this case, when the ratio ϕ/L value is controlled so that the relationship (I) is satisfied, the tensile stress applied to the yarns becomes minimum and the resultant air bag exhibits a maximum burst strength.

Preferably, the ratio ϕ/L value is 0.5 to 2.90, more preferably 0.6 to 2.50.

In the relationship (I) of the present invention, the straight line distance represented by ϕ is variable depending on the dimensions of the air bag and the capacity of the inflator and preferably is in the range of from 130 to 550 mm, more preferably from 170 to 500 mm.

Generally, in the reinforcing belts usable for the air bag of the present invention, the direction of the longitudinal center line of each belt preferably intersects both the warp and weft directions of the woven fabric piece from which the reinforcing belt is formed, at a bias angle. This arrangement contributes to enhancing the reinforcing effect of the reinforcing belt.

As mentioned above, in an embodiment of the air bag of the present invention, the two end portions of each reinforcing belt are respectively connected to the top reinforcing cloth and the bottom reinforcing cloth. In this case, the top reinforcing cloth is arranged on and seam-joined to the inside face of the top cloth and the bottom reinforcing cloth is arranged on and seam-joined to the inside face of the bottom cloth.

The top reinforcing cloth and the bottom reinforcing cloth may be in a substantially circular form or a polygonal form, for example, an octagonal form.

The warp or weft direction of the woven fabric piece from which the top cloth, top reinforcing cloth, bottom cloth or bottom reinforcing cloth is formed, can be set forth in consideration of the performances required to the air bag and the direction of the longitudinal center line of the reinforcing belt.

Generally, in the air bag of the present invention, the warp or weft direction of the woven fabric piece from which at least one of the top cloth and the bottom cloth is formed, is parallel to the longitudinal center line direction of the reinforcing belt. By making parallel the warp or weft direction of the woven fabric piece from which the top or bottom cloth is formed, and the longitudinal center line direction of the reinforcing belt to each other, the burst-starting points of the air bag can be concentrated at the outermost circumferential seam line of the cloth and thereby the burst strength of the entire air bag can be enhanced.

Regarding the top cloth and the bottom cloth, the one which can have a higher burst strength than the other, is the bottom cloth. Accordingly, the warp or weft direction of the woven fabric piece from which the bottom cloth is formed is preferably parallel to the longitudinal center line direction of the reinforcing belt and the bottom cloth is seam-joined to the reinforcing belt in the above-mentioned direction. In this case, the warp and weft directions of the woven fabric piece, from which the top cloth is formed, preferably intersect, at a bias angle, the longitudinal center line direction of the reinforcing belt.

When they intersect each other at a bias angle, the intersecting angle is preferably 20 degrees to 70 degrees, more preferably 30 degrees to 60 degrees, still more preferably 40 degrees to 50 degrees. In case where the air bag is practically employed and bursted, the generation of burst-starting points in the bottom cloth contributes to enhancing the safety for the occupants in comparison with burst starting point generated in the other cloth.

In the air bag of the present invention, the reinforcing clothes are seam-joined to both the top cloth and the bottom cloth so as to satisfy the relationship (I). In this case, preferably the ratio $\phi a/L$ value of the top cloth side is close to the $\phi b/L$ value of the bottom cloth side, the warp or weft direction of the bottom cloth-forming woven fabric piece is parallel to the longitudinal center line direction of the reinforcing belt, and the warp or weft direction of the top cloth-forming woven fabric piece intersects the longitudinal center line direction of the reinforcing belt at a bias angle.

For example, preferably, the warp direction of the circular top cloth-forming woven fabric piece is parallel to the warp direction of the top reinforcing cloth-forming woven fabric piece, and the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the bottom reinforcing cloth-forming woven fabric piece at a bias angle.

Also, preferably, the warp direction of the circular top cloth-forming woven fabric piece is parallel to the warp direction of the reinforcing belt-forming woven fabric piece, and the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the reinforcing belt-forming woven fabric piece at a bias angle.

Further, preferably the warp direction of each of the top and bottom reinforcing cloth-forming woven fabric pieces intersects the longitudinal center line direction of the reinforcing belt seam-joined to the top and bottom reinforcing cloths at a bias angle.

Further, preferably the longitudinal center line direction of the reinforcing belt intersects the warp and weft directions of the reinforcing belt-forming woven fabric belt at a bias angle, the warp directions of the circular top cloth, and the reinforcing belt and the top reinforcing cloth located on the top cloth, are parallel to each other, the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the bottom reinforcing cloth-forming woven fabric piece at a bias angle, and the warp directions of the bottom reinforcing cloth-forming woven fabric piece and the reinforcing belt-forming woven fabric piece are parallel to each other.

Furthermore, the warp direction of the circular top cloth-forming woven fabric piece and the top reinforcing cloth-forming woven fabric piece are parallel to each other, and the warp direction of the circular bottom cloth-forming woven fabric piece intersect the warp direction of the bottom reinforcing cloth-forming woven fabric piece at a bias angle.

In the air bag of the present invention, there are no limitation on the type, structure and thickness of the woven fabric pieces for forming the elements of the air bag, and thus those matters can be set forth so as to effectively attain the objects of the present invention.

For example, it is preferable that the top reinforcing cloth and the reinforcing belts located on the circular top cloth be formed from one and the same woven fabric piece, the bottom reinforcing cloth and the reinforcing belts located on the circular bottom cloth be formed from one and the same woven fabric piece, and each of the reinforcing belts on the circular top cloth be seam-joined to a corresponding one of the reinforcing belts on the circular bottom cloth.

In the air bag of the present invention, there is no limitation on the form of the outermost circumferential closed seam line of the top reinforcing cloth and/or the bottom reinforcing cloth, as long as the seam line is closed. Preferably, the outermost circumferential closed seam line is in a substantially circular form.

Also, the closed outermost circumferential seam line can be in a substantially regular square form.

In this case, preferably, each side of the regular square is at right angles to the longitudinal center line direction of the reinforcing belt corresponding to the side.

In an embodiment of the reinforcing belt-provided air bag of the present invention, the two end portions of each reinforcing belt are connected to a top belt catcher and a bottom belt catcher respectively arranged on the inside faces of the top cloth and the bottom cloth. In this case, the top and bottom reinforcing cloths respectively may be arranged on and seam-joined to the inside faces of the top cloth and the bottom cloth, or arranged on and seam-joined to the outside faces thereof.

In the above-mentioned embodiment, the top and bottom belt catchers may be in a substantially circular form. Alternatively, the top and bottom belt catchers are in a polygonal form.

Preferably, the warp direction of the circular top cloth-forming woven fabric piece is parallel to the warp direction of the top belt catcher-forming woven fabric piece, and the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the bottom belt catcher-forming woven fabric piece at a bias angle.

Also, preferably, the warp direction of the circular top cloth-forming woven fabric piece is parallel to the warp direction of the reinforcing belt-forming woven fabric piece, and the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the reinforcing belt-forming woven fabric piece at a bias angle.

Further, the warp directions of the top and bottom belt catcher-forming woven fabric pieces respectively intersect the longitudinal center line directions of the reinforcing belts seam-joined to the belt catchers at a bias angle.

Further, preferably, the longitudinal center line directions of the reinforcing belts respectively intersect the warp and weft directions of the reinforcing belt-forming woven fabric pieces at a bias angle, the warp directions of the woven fabric pieces from which the circular top cloth, and the reinforcing belts and top belt catcher on the circular top cloth are formed, are parallel to each other, the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the bottom belt catcher-forming woven fabric piece at a bias angle, and the warp directions of the woven fabric pieces from which the bottom belt catcher and the reinforcing belts are formed are parallel to each other.

Further, preferably, the warp direction of the circular top cloth-forming woven fabric piece is parallel to the warp direction of the top belt catcher-forming woven fabric piece, and the warp direction of the circular bottom cloth-forming woven fabric piece intersects the warp direction of the bottom belt catcher-forming woven fabric piece.

In the air bag of the present invention having belt catchers and reinforcing belts, preferably, the top belt catcher and the reinforcing belts on the circular top cloth are formed from one and the same woven fabric piece, the bottom belt catcher and the reinforcing belts on the circular bottom cloth are formed from one and the same woven fabric piece, and the reinforcing belts on the circular top cloth are seam-joined to the corresponding reinforcing belts on the circular bottom cloth.

In the air bag of the present invention, it is preferable that the bottom cloth and the inflator-joining circular hole satisfy the relationship (II):

$$32 \leq (\phi k - \phi c)/2 \leq 123 \qquad \text{(II)}$$

In the relationship (II), ϕk represents a shortest straight line distance in mm between two points at which a straight line drawn parallel to the warp or weft direction of the circular bottom cloth-forming woven fabric piece, in which direction, the woven fabric piece exhibits a tensile strength lower than in the other direction, intersects the closed outermost circumferential seam line, and ϕc represents a diameter in mm of the inflator-joining circular hole.

With respect to the distances between a outer of a hole through which a high pressure gas is blown from the inflator and the outermost circumferential seam line measured in the warp and weft directions of the bottom cloth-forming woven fabric piece, the burst strength of the air bag depends on the value of one of the above-mentioned distances in one direction in which the bottom cloth exhibits a lower tensile elongation than in the other direction. This dependency is explained by the fact that the burst-starting points of the bottom cloth are not always generated in the bias directions thereof and are generated in one direction of the warp and weft directions in which the bottom cloth exhibits a lower tensile elongation than in the other direction, more particularly are generated on the outermost circumferential seam line on the

bottom cloth in warp or weft direction in which the bottom cloth exhibits a lower tensile elongation than in the other direction.

The burst-starting points are never generated on the outermost circumferential seam lines in bias directions of the bottom cloth-forming woven fabric piece, because in the bias direction, the tensile elongation of the bottom cloth is high. Namely, the high pressure gas blown from the inflator immediately impacts an apron and generates a large tensile stress on the outermost circumferential seam line in the warp and weft directions of the bottom cloth-forming woven fabric piece and in a direction at right angles to the outermost circumferential seam line. This is because the seam tensile strength of the outermost circumferential seam line is very small in comparison with the tensile strength of the woven fabric piece per se. Therefore, the air bag bursts on outermost circumferential seam line. In this case, the bursting easily occurs in a direction in which the bottom cloth exhibits a lower tensile elongation than in another directions. This is due to the fact that from the generation of a tensile stress in the outermost circumferential seam line until the bursting occurs, the woven fabric piece elongates in a normal line direction of the outermost circumferential seam line to absorb the inflating energy and to prevent the bursting of the air bag.

If the ultimate elongation of the bottom cloth-forming woven fabric piece in the warp direction is the same as that in the weft direction, the burst-starting points on the outermost circumferential seam line are created in one of the wrap and weft directions in which direction the yarns have a smaller diameter than that in the other direction even if the difference in diameter is small.

In the relationship (II), if the (ϕk - ϕc)/2 value is less than 32 mm, the resultant air bag exhibits a reduced burst strength, and if the (ϕk - ϕc)/2 value is more than 123 mm, the bursting no longer occurs in the outermost circumferential seam line and the location of the burst-starting points shift from the outermost circumferential seam line to a circular circumferential seam line in which the circumferential edge portions of the top and bottom clothes are seam-joined to each other, and thus the resultant air bag exhibits a reduced burst strength. The (ϕk - ϕc)/2 value is preferably in the range of from 45 to 110 mm. The air bag satisfying the relationship (II) can exhibit a further enhanced burst strength.

In the air bag of the present invention, the outermost circumferential closed seam lines of the top and bottom reinforcing clothes preferably have a stitching pitch Pϕ in the range of from 1.0 to 2.5 mm, more preferably from 1.2 to 2.3 mm.

An embodiment of the air bag of the present invention having the reinforcing belts is shown in Figures 2A to 2C.

In the air bag of the present invention as indicated in Figs. 2A to 2C, a substantially circular top cloth 1 formed from a woven fabric piece and a substantially circular bottom cloth 2 formed from a woven fabric piece are superimposed on each other and seam-joined to each other at the circumferential edge portions 3 thereof by a seam line 3a.

In a center portion of the circular bottom cloth 2, a circular hole 4 for joining an inflator 4a is formed.

A circular top reinforcing cloth 5 consisting of two woven fabric pieces is arranged on the inside face of the center portion of the circular top cloth 1 and seam-joined thereto by a plurality of concentrically circular seam lines located around the center 10 of the top cloth 1. An outermost circumferential circular seam line 11 is located at the outermost circumference of the seam lines. The outermost circumferential circular seam line 11 has a diameter ϕa.

A circular bottom reinforcing cloth 5 consisting of two woven fabric pieces is arranged on the inside face of the circular bottom cloth 2 and around the inflator-joining circular hole 4, and seam joined thereto by a plurality of concentrically circular seam lines around the center 15 of the bottom cloth 2, and an outermost circumferential circular seam line 16 is formed at the outermost circumference of the seam lines. This outermost circumferential circular seam line 16 has a diameter ϕb.

An end portion of each of the reinforcing belts 7 is seam-joined to the circular top reinforcing cloth 5 by seam lines 8, and the opposite end portion thereof is seam-joined to the circular bottom reinforcing cloth 6 by seam lines 9.

In the air bag as shown in Figs. 2A to 2C, the distance L of each reinforcing belt 7 is a straight line distance between a point 7b at which a longitudinal center line 7a of each reinforcing belt 7 intersects the outermost circumferential circular seam line 11 of the top reinforcing cloth 5 and a point 7c at which the longitudinal center line 7a intersects the outermost circumferential circular seam line 16 of the bottom reinforcing cloth 6, measured along the longitudinal center line 7a.

In the reinforcing belt-provided air bag of the present invention as shown in Figs. 2A to 2C, the top reinforcing cloth and the reinforcing belts satisfy the relationship:

$$0.45 \leq \phi a/L \leq 2.95$$

and the bottom reinforcing cloth and the reinforcing belts satisfy the relationship:

$0.45 \leq \phi b/L \leq 2.95$

As indicated in Fig. 2A, the warp direction Ka of the top cloth 1-forming woven fabric piece and the warp direction Kb of the top reinforcing cloth 5-forming woven fabric piece are parallel to each other.

Also, as indicated in Fig. 2B, the warp direction Kd of the bottom cloth 2-forming woven fabric piece and the warp direction Ke of the bottom reinforcing cloth 6-forming woven fabric piece intersect each other at a bias angle. Also, as indicated in Figs. 2A and 2B, the warp direction Ka of the top cloth 1-forming woven fabric piece and the warp direction Kc of each reinforcing belt 7-forming woven fabric piece are parallel to each other, and the warp direction Kd of the bottom cloth 2-forming woven fabric piece and the warp direction Kc of each reinforcing belt 7-forming woven fabric piece intersect each other at a bias angle. The intersecting angle is preferably in the range of from 20 degrees to 70 degrees, more preferably 30 to 60 degrees, still more preferably 40 to 50 degrees, as mentioned above. Further, the warp and weft directions of the reinforcing belt-forming woven fabric pieces each intersect the longitudinal center line direction of each reinforcing belt. Namely, the woven fabric for forming the reinforcing belts is cut in a bias direction into a belt form, and the cut woven fabric pieces are used as the reinforcing belts. The reinforcing belts prepared in the above-mentioned manner exhibits a large tensile elongation when the air bag is inflated, and thus can absorb the impact energy applied to the air bag with high efficiency.

The air bag as indicated in Figs. 3A to 3C has the same constitution as that indicated in Figs. 2A to 2C, with the following exceptions. Namely, the diameter ϕa of the outermost circumferential circular seam line 11 formed on the circular top reinforcing cloth 5 is relatively small and, as indicated in Fig. 3C, the distance L is relatively large. Therefore, the ratio $\phi a/L$ value does not satisfy the relationship (I). The diameter ϕb of the outermost circumferential circular seam line 16 of the circular bottom reinforcing cloth 6 is, however, relatively large and thus the ratio $\phi b/L$ value satisfies the relationship (I).

Figs. 4A to 4B show a reinforcing belt-provided air bag which is the same as that of Figs. 2A to 2C with the following exceptions. Namely, in the air bag as shown in Figs. 4A and 4B, the top and bottom reinforcing cloths 5 and 6 are in an octagonal form, and a plurality of concentrically closed seam lines, especially an outermost circumferential seam line of the top and bottom reinforcing cloths are in a substantially regular square form. In this case, the ϕa value of the outermost circumferential regular square seam line 11 of the top reinforcing cloth 5 is equal to the length of a side of the regular square, and the ϕb value of the outermost circumferential regular square seam line 16 of the bottom reinforcing cloth 6 is equal to a side length of this regular square. Even in this case, the ϕa, L and ϕb values should be adjusted, so that the resultant ratio $\phi a/L$ and $\phi b/L$ values fall each in the range of from 0.45 to 2.95.

The reinforcing belt-provided air bag as shown in Figs. 5A to 5C is the same as that in Figs. 2A to 2C with the following exceptions. Namely, the top reinforcing cloth 5 and the reinforcing belt halves 7d are formed from at least one piece (for example, two pieces) of the same woven fabric, the bottom reinforcing cloth 5 and the reinforcing belt halves 7e are formed from at least one piece (for example, two pieces) of the same woven fabric and as shown in Fig. 5C, the reinforcing belt halves 7d and 7c are seam-joined to each other by the seam lines 7f.

In this case, the ϕa, ϕb and L values should be adjusted so that the resultant ratio $\phi a/L$ and $\phi b/L$ values fall each in the range of from 0.45 to 2.95.

The reinforcing belt-provided air bag of the present invention as indicated in Figs. 6A to 6C is the same as that in Figs. 2A to 2C with the following exceptions. Namely, a circular top reinforcing cloth 5 is arranged on an inside face of the circular top cloth 1, a circular belt catcher 17 having a smaller diameter than that of the circular top reinforcing cloth 5 is arranged on the top reinforcing cloth 5, and the cloths and the catcher are seam joined to each other by a plurality of concentrically circular seam lines around the center 10 of the circular top cloth 1. The outermost circumferential circular seam line 11 is formed so as to seam-join the circular top reinforcing cloth 5 and the circular top cloth 1 to each other.

An end portion of each reinforcing belt 7 is seam-joined to the top belt catcher 17 by seam lines 19.

Also, a circular bottom reinforcing cloth 6 is arranged on an inside face of the circular bottom cloth 2, and on this bottom reinforcing cloth 6, a circular bottom belt catcher 18 having a smaller diameter than that of the bottom reinforcing cloth 6 is arranged, and they are seam-joined to each other around the inflator-joining circular hole 4 by a plurality of concentrically circular seam lines. By the outermost circumferential circular seam line, the bottom reinforcing cloth and the bottom cloth are seam-joined to each other.

Also, the opposite end portion of each reinforcing belt 7 is seam-joined to the circular bottom belt catcher 18 by seam lines 20.

In the air bag as indicated in Figs. 6A to 6C, the distance L in the relationship (I) is a straight line distance, when a reinforcing belt 7 are superimposed on the top reinforcing cloth 5 and the bottom reinforcing cloth 5 as shown in Figs. 6A and 6B, between a point 7b shown in Fig. 6A at which the longitudinal center line 7a of the reinforcing belt 7 intersects the outermost circumferential closed seam line 11 of the top reinforcing cloth, and a point 7c shown in Fig. 6B at which the longitudinal center line 7a intersects the outermost circumferential closed seam line 16 of the bottom reinforcing cloth.

As shown in Fig. 6A, the warp direction Ka of the top cloth 1-forming woven fabric piece, the warp direction Kb of the top reinforcing cloth 5-forming woven fabric piece and the warp direction Kf of the top belt catcher 17-forming woven fabric piece are parallel to each other, and the warp direction Kc of each reinforcing belt 7-forming woven fabric piece is parallel to the Ka, Kb and Kf, whereas the warp direction Kc and the longitudinal center line direction of each reinforcing belt intersect each other at a bias angle, and each reinforcing belt 7 has a high tensile elongation in the longitudinal center line direction thereof. By being formed in the above-mentioned manner, the resultant top cloth side portion of the air bag shown in Fig. 6A exhibits an excellent burst strength.

Additionally, the warp direction Kb of the bottom reinforcing cloth 6-forming woven fabric piece, the warp direction Kg of the bottom belt catcher 18-forming woven fabric piece and the warp direction Kc of each reinforcing belt 7-forming woven fabric piece are parallel to each other, and the warp direction Kd of the bottom cloth 2-forming woven fabric piece intersects the above-mentioned warp directions Kb, Kg and Kc, each at a bias angle. In this arrangement of these warp directions, when the resultant air bag is burst by the inflation thereof, the burst-starting points are generated in the bottom cloth side of the air bag, and thereby the burst strength of the top cloth side can be enhanced and the bursting can be prevented.

In Fig. 6C, the straight line distances ϕa and ϕb relating to the outermost circumferential closed seam lines of the top and bottom reinforcing cloths and the straight line distance L relating to the reinforcing belts are such that the ratio $\phi a/L$ and $\phi b/L$ values fall in the range of from 0.45 to 2.95.

In the air bag of the present invention, as illustrated above with reference to Figs. 2B and 6B, preferably, the longitudinal center line direction of each reinforcing belt 7 is adjusted so as to intersect the warp and weft directions of the reinforcing belt-forming woven fabric piece at bias angles, and also intersects the warp directions of the bottom reinforcing cloth 2-forming woven fabric piece and the bottom belt catcher 18-forming woven fabric piece.

Where the longitudinal center line direction of each reinforcing belt 7 is parallel to the warp or weft direction of the reinforcing belt 7, the possible elongation value of the belt 7 is small and thus when the air bag is inflated, the reinforcing belts cannot fully absorb the impact energy and the air bag exhibits an unsatisfactory burst strength. Also, where the longitudinal center line direction of each reinforcing belt is parallel to the warp or weft direction of the belt catcher-forming woven fabric piece, the possible elongation value of the belt catcher is small and thus the belt catcher cannot fully absorb the impact energy and the air bag exhibits an unsatisfactory burst strength.

As indicated in Figs. 2A and 2B, or Figs. 6A and 6B, preferably the top cloth and the bottom cloth are seam-joined together in such a manner that the warp direction of the top cloth-forming woven fabric piece inclined at an angle of 30 to 60 degrees from the warp direction of the bottom cloth-forming woven fabric piece. If this inclination angle is less than 30 degrees or more than 60 degrees, when the resultant air bag is inflated, sometimes, the impact stress applied to the top and/or bottom cloth in the warp and/or weft direction thereof is concentrated to the circumferential double chain seam line 3a of the air bag, and the elongation of the top and/or bottom cloth is hindered. Therefore, the resultant air bag sometimes exhibits an unsatisfactory burst strength. The inclination angle is more preferably 40 to 50 degrees.

In the air bag of the present invention, preferably, the stitching pitch of the outermost circumferential seam lines of the top and bottom reinforcing clothes is 1.0 to 2.5 mm, more preferably 1.5 to 2.0 mm. If this stitching pitch is less than 1.0 mm, sometimes, the sewing operation is difficult, thus the resultant seam line becomes uneven and the resultant air bag exhibits an unsatisfactory burst strength. If the stitching pitch is more than 2.5 mm, the bursting stress is concentrated into each stitch having the large pitch, and thus the resultant air bag sometimes exhibits an unsatisfactory burst strength. Further, the seam lines other than the outermost circumferential seam lines preferably have a stitching pitch in the same range as mentioned above. The sewing yarns for the seam-joining are preferably selected from those having a large ultimate elongation and a low modulus of elasticity. Particularly, sewing yarns composed of nylon 66 multifilament yarns having a thickness of 420 to 1,260 deniers are employed for the present invention. Also, polyester sewing yarns can be employed for the pr sent invention.

In the air bag of the present invention, preferably, the top cloth and the bottom cloth are formed from a woven fabric not coated with a resin, namely a non-coated woven fabric. A resin-coated fabric has an increased weight and thus is not preferable for the present invention. The yarns for forming the top and

bottom cloth-forming woven fabric preferably have a total thickness of 150 to 550 deniers. If the total thickness is less than 150 deniers, the resultant air bag sometimes exhibit an unsatisfactory burst strength even when the above-mentioned improvement for the seam-joining is applied. Also, the total thickness is more than 550 deniers, the resultant air bag sometimes exhibits an unsatisfactory feel, weight and size. The total thickness is more preferably 200 to 450 deniers.

Preferably, the individual filament thickness of the filament yarns for forming the top and bottom cloth-forming woven fabric is 0.5 to 6 deniers, more preferably 1 to 3 deniers. If the individual filament thickness is more than 6 deniers, the resultant air bag sometimes exhibits an unsatisfactory feel. Also, if the individual filament thickness is less than 0.5 denier, the resultant air bag sometimes exhibits an unsatisfactory burst strength even when the above-mentioned improvement is applied to the seam-joining.

In the air bag of the present invention the top reinforcing cloth and the top belt catcher are preferably formed from a non-coated fabric. Since the top reinforcing cloth and the top belt catcher seam-joined to the top cloth are located far from the inflator, it is not always necessary to coat the woven fabric for the cloth and the catcher with a resin. In this case, the use of a non-coated woven fabric is effective for making the resultant air bag light weight and compact. The bottom reinforcing cloth and the bottom belt catcher on the bottom cloth side are preferably formed from a coated fabric. In this case, if a non-coated fabric is used, the resultant air bag is easily broken at a portion thereof surrounding the inflator. The top and bottom reinforcing clothes and belt catchers are preferably formed from a woven fabric made from yarns having a total thickness of 150 to 550 deniers, and the filament yarns for forming the woven fabric preferably have an individual filament thickness of 0.5 to 6 deniers.

In the air bag of the present invention, by forming all of the top cloth, the bottom cloth, the top reinforcing cloth, the bottom reinforcing cloth, the reinforcing belts and optionally the belt catchers from polyester woven fabrics, a high compactness can be imparted to the resultant air bag. However, nylon 66 woven fabrics may be employed in place of the polyester woven fabrics. Namely, since the polyester filaments have a higher specific gravity than that of the Nylon 66 filaments, the polyester woven fabric has a volume or thickness smaller than that of another woven fabric having the same bias weight as and a lower filament specific gravity than those of the polyester woven fabric and exhibits an excellent calender processing property. Therefore, the use of the non-coated polyester woven fabric can reduce the gas permeability of the woven fabric by applying the calender treatment thereto. Accordingly, when the polyester woven fabric is utilized without resin coating, the resultant air bag can fully protect the occupant from the inflation gas. Also, the polyester woven fabric is advantageous in that the inside pressure of the resultant air bag can be accurately controlled.

The polyester woven fabric is preferably formed from polyester multifilament yarns. The polyester for forming the polyester filaments includes, for example, polyethylene terephthalate, polybutylene terephthalate, polyhexylene terephthalate, polyethylene naphthalate, polybutylene naphthalate, polyethylene-1,2-bis(phenoxy)ethane-4,4'-dicarboxylate, and copolymers, for example, polyethylene, isophthalate copolymers, polybutylene terephthalate/naphthalate copolymers, and polybutylene terephthalate/decane dicarboxylate copolymers. Among the above-mentioned polyesters, polyethylene terephthalate, which has well-balanced mechanical properties and fiber-forming properties, is preferably employed for the present invention.

Further, the polyester filaments preferably have a dry heat shrinkage of 3 to 12% at a temperature of 150 °C. If the dry heat shrinkage at a temperature of 150 °C is more than 12%, the resultant woven fabric exhibits a too large shrinkage due to a setting or calendering after scouring, and thus the even shrinkage of the fabric is rather restricted and gaps formed between the yarns in the fabric becomes large. Therefore, it becomes difficult to produce a woven fabric having a low air permeability and a high smoothness.

Also, if the dry heat shrinkage is less than 3%, it is impossible to produce a woven fabric having a low air permeability and a high smoothness, because the shrinkage of the resultant woven fabric due to the setting or calendering after scouring is too small. The dry heat shrinkage of the polyester filaments at a temperature of 150 °C is more preferably 4 to 11%.

Also, the polyester filaments preferably have a shrinkage of 1 to 7%, more preferably 1 to 6%, in boiling water. If the boiling water shrinkage is more than 7%, the resultant woven fabric is shrunk to an excessively large extent during a scouring or setting procedure and thus wrinkles are frequently generated on the fabric and the calender processability of the fabric is reduced. Therefore, it is difficult to obtain a woven fabric having a low air permeability and a high smoothness.

If the boiling water shrinkage is less than 1%, the shrinkage of the resultant woven fabric during scouring or setting procedure is too low, and thus the resultant woven fabric does not exhibit a low air permeability and a high smoothness.

In the polyester woven fabric usable for the air bag of the present invention, preferably, the woven fabric exhibits a cover factor of 1,050 to 1,400 both in the warp and weft directions thereof. Also, it is preferable that the warp and weft densities of the woven fabric be equal to or close to each other.

The cover factor of the woven fabric in the warp direction refers to a product of a square root of the thickness in denier of the warp yarns with a warp density in yarns/2.54 cm (inch). The cover factor of the woven fabric in the weft direction refers to a product of a square root of the thickness in denier of the weft yarns with a warp density in yarns/2.54 cm (inch). When the cover factor is less than 1,050, the resultant woven fabric exhibits an unsatisfactorily airtightness. Also, when the cover factor is more than 1,400, the resultant woven fabric exhibits a high stiffness and a poor feel and the airtightness of the fabric is not satisfactorily enhanced. A more preferable cover factor is 1,100 to 1,350.

Even where the polyester filament woven fabric has the cover factor falling within the above-mentioned range, if the woven fabric has an extremely high warp density and a reduced weft density, the airtightness thereof is not satisfactorily high and the touch thereof undesirably becomes stiff. Also, this type of woven fabric exhibits an extremely reduced burst strength in one specific direction and thus is not suitable for the air bag.

The non-coated polyester woven fabric usable for the air bag of the present invention is preferably one obtained by applying a calender treatment to the polyester woven fabric in such a manner that at least one surface of the woven fabric is brought into contact with a metal roll in the calendering machine. The metal roll preferably has preferably a surface temperature of 150 to 220 °C, more preferably 160 to 200 °C, under a roll pressure of 500 kg/cm or more, more preferably 550 to 1,000 kg/cm at a roll speed of 1 to 50 m/min., more preferably 2 to 25 m/min., to obtain better results. In this calendering treatment, to obtain a satisfactory heat-pressing effect, the woven fabric is preferably preheated or calendered at a low speed. The calendering treatment is carried out at least once, or 2 times or more.

The non-coated polyester woven fabric preferably exhibits an air permeability of 0.01 to 0.4 ml/cm^2/sec./0.5 inch Aq, as determined by the Frasil method. When the air permeability is more than 0.4 ml/cm^2/sec./0.5 inch Aq, the resultant air bag exhibits a reduced airtightness and has a high possibility of breaking upon inflating. Therefore, the risk of the occupants's face being burned by the high temperature gas is increased. Also, the high air permeability causes the control of the inside pressure of the air bag only by the vent holes to be difficult. Also, if the air permeability is less than 0.01 ml/cm^2/sec./0.5 inch Aq, the fiber packing of the resultant woven fabric becomes excessively high, the tear strength of the woven fabric falls and as a result, the burst strength of the resultant woven fabric falls. A more preferable air permeability is 0.02 to 0.3 ml/cm^2/sec./0.5 inch Aq.

In the air bag of the present invention, as mentioned above, the bottom reinforcing cloth and optionally the bottom belt catcher located on the bottom cloth side are preferably formed from a coated woven fabric. This is because the coated fabric can effectively cut off the high temperature gas upon inflating. The coated woven fabrics usable for this purpose include woven fabrics coated or impregnated with a silicone rubber or chloroprene rubber. As the silicone rubber, an addition reaction type silicone rubber containing a catalyst is preferably utilized. Particularly, dimethyl silicone rubbers, methylvinyl silicone rubbers, methylphenyl silicone rubbers and fluorosilicone rubbers can be used. Among the above-mentioned silicone rubbers, the methyl silicone, which has excellent mechanical properties, a low price and good working properties, is more preferably used. The silicone rubber optionally contains a flame retardant, an inorganic additive such as silica and a filler.

In the air bag of the present invention, by seam joining the reinforcing cloths and optionally the belt catchers so that the outermost circumferential seam lines of the reinforcing cloth arranged on at least one of the top cloth side and the bottom cloth side and the reinforcing belts satisfy the relationship (I), the location of the outermost circumferential seam line at which the burst-starting points are generated and along which the burst proceeds, can be made far from the center of the top or bottom cloth, and thereby the bursting stress can be borne by the large seam line portion so as to reduce the burst stress per unit area of the seam line portion, and simultaneously the absorption of the impact energy can be enhanced and the tensile stress applied to the sewing yarns upon inflating can be made a minimum. According, an air bag having an enhanced burst strength can be obtained.

Further, in this case, by adjusting the value of ϕ (ϕa and ϕb) preferably to 130 to 550 mm, more preferably 170 to 500 mm, the outermost circumferential seam line, in which the bursting stress is borne, can be expanded so that the bursting stress is dispersed in the outermost circumferential seam line portion, and simultaneously the impact en rgy can be absorbed in a large area. Therefore, an air bag having an excellent burst strength can be obtained.

Further, by arranging the warp or weft direction of the bottom cloth-forming woven fabric piece in parallel with the longitudinal center line direction of each reinforcing belt, even when the resultant air bag

bursts, the burst-starting points can be generated in the outermost circumferential seam line of the belt catcher on the bottom cloth side to obtain an air bag having an enhanced safety for the occupants.

Furthermore, in the air bag of the present invention, by seam-joining the reinforcing cloths and optionally the belt catchers in a manner satisfying the relationship (I) in both the top cloth side and the bottom cloth side, and in this case, by arranging the warp or weft direction of the bottom cloth-forming woven fabric piece in parallel with the longitudinal center line direction of each reinforcing belt, an air bag having an excellent burst strength, a superior form-retention upon inflation and high safety can be obtained.

EXAMPLES

The present invention will be further explained by way of the following specific examples.

In the examples, the burst strength of the air bag was measured in accordance with the following test method.

(1) Burst Strength

The burst strength (kg/cm^2G) of an air bag was measured by rapidly blowing high pressure nitrogen gas thereinto at room temperature.

Examples 1 to 8

In each of Examples 1 to 8, polyester multifilament yarns (trademark: Tetoron, made by Teijin Limited 420 deniers/250 filaments) and nylon 66 multifilament yarns (made by Akzo 420 deniers/72 filaments), each having the physical properties as shown in Table 1, were woven to form a plain weave having a warp and weft density of 57 yarns/inch. The resultant woven fabric was subjected to a scouring step and then a heat-setting step, and finished to such an extent that the resultant woven fabric exhibited a cover factor of 1,230 in the warp and weft directions. Further, the woven fabric was subjected to a calendering treatment at one side surface thereof, to provide a high airtightness woven fabric having an air permeability of 0.05 $ml/cm^2/sec./0.5$ inch Aq (Frasil method).

Some of the woven fabrics were coated with a silicone rubber in a coating amount of 40 g/m^2.

The above-mentioned woven fabric was used to provide an air bag having reinforcing belts for a driver's seat.

The constitution details and results of the burst strength test of the air bag are shown in Table 1.

Table 1

Item	Example No.	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
Top cloth	Type of top cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	ϕa	300	300	300	135	240	150	400
	L	250	250	250	355	255	270	200
	$\phi a/L$	1.20	1.20	1.20	0.38	0.94	0.56	2.00
	Relationship between reinforcing belt longitudinal center line direction and Ka	Bias intersection	Bias intersection	Bias intersection	Bias intersection	Parallel	Parallel	Bias intersection
	Type of top reinforcing cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Continuous single structure with belts	Continuous single structure with belts	Continuous single structure with belts	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Kb	Bias intersection	Bias intersection				Bias intersection	Parallel
Bottom cloth	Type of bottom cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	ϕb	300	300	300	250	500	200	400
	L	250	250	250	200	160	270	200
	$\phi b/L$	1.20	1.20	1.20	1.25	3.13	0.74	2.00
	Relationship between reinforcing belt longitudinal center line direction and Kd	Parallel	Parallel	Parallel	Parallel	Bias intersection	Bias intersection	Parallel
	Type of bottom reinforcing cloth	Silicone rubber-coated polyester woven fabric	Silicone rubber-coated Nylon 66 woven fabric	Continuous single structure with belts	Continuous single structure with belts	Continuous single structure with belts	Silicone rubber-coated polyester woven fabric	Silicone rubber-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Ke	Bias direction	Bias direction				Bias direction	Warp direction

Table 1 (Continued)

Item	Example No.	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
Intersecting angle (degree) of Ka of top cloth with Kd of bottom cloth		45	45	45	45	45	45	45
Rein-forcing belts	Type of reinforcing belt woven fabric	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Kc	Bias intersection	Bias intersection	Bias intersection	Bias intersection	Bias intersection	Bias intersection	Parallel
Burst strength (kg/cm^2 G)		2.0	2.2	2.0	2.2	1.9	1.8	2.0
General evolution		Good	Good	Good	Good	Good	Good	Good

[Note]
Ka ... Warp direction of top cloth-forming woven fabric
Kb ... Warp direction of top reinforcing cloth-forming woven fabric
Kc ... Warp direction of reinforcing belt-forming woven fabric
Kd ... Warp direction of bottom cloth-forming fabric
Ke ... Warp direction of bottom reinforcing cloth-forming woven fabric

Comparative Examples 1 to 7

In each of Comparative Examples 1 to 7, the plain weave as shown in Table 2 was produced from the same polyester multifilament yarn or nylon 66 multifilament yarns as in Examples 1 to 7, and subjected to a scouring treatment and a heat setting tr atment. Further, a calendering treatment was applied to one

surface of the woven fabric to provide a woven fabric having a high airtightness. Some of the woven fabrics were coated with a silicone rubber in a coating amount of 40 g/m^2. The resultant woven fabric was converted to an air bag having reinforcing belts.

The constitution details and the result of the burst strength test of the air bag are shown in Table 2.

Table 2

Item	Comparative Example No.	Comparative Example 1	2	3	4	5	6	7
Top cloth	Type of top cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	ϕa	140	140	140	140	480	510	540
	L	350	350	350	350	160	165	180
	$\phi a/L$	0.40	0.40	0.40	0.40	3.00	3.10	3.00
	Relationship between reinforcing belt longitudinal center line direction and Ka	Parallel	Parallel	Parallel	Bias intersection	Parallel	Bias intersection	Parallel
	Type of top reinforcing cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Continuous single structure with belts	Continuous single structure with belts	Continuous single structure with belts	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Kb	Parallel	Parallel				Bias intersection	Bias intersection
Bottom cloth	Type of bottom cloth	Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	ϕb	140	140	140	140	480	510	560
	L	350	350	350	350	160	165	180
	$\phi b/L$	0.40	0.40	0.40	0.40	3.00	3.10	3.10
	Relationship between reinforcing belt longitudinal center line direction and Kd	Warp direction	Warp direction	Warp direction	Warp direction	Bias direction	Warp direction	Bias direction
	Type of bottom reinforcing cloth	Silicone rubber-coated polyester woven fabric	Silicone rubber-coated Nylon 66 woven fabric	Continuous single structure with belts	Continuous single structure with belts	Continuous single structure with belts	Silicone rubber-coated polyester woven fabric	Silicone rubber-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Ke	Warp direction	Warp direction				Bias direction	Warp direction

Table 2 (Continued)

Item		Comparative Example No.	Comparative Example 1	2	3	4	5	6	7
Intersecting angle (degree) of Ka of top cloth with Kd of bottom cloth			0	0	0	45	45	45	45
Rein-forcing belts	Type of reinforcing belt woven fabric		Non-coated polyester woven fabric	Non-coated Nylon 66 woven fabric	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated and silicone rubber-coated polyester woven fabrics (2 sheets)	Non-coated polyester woven fabric	Non-coated polyester woven fabric
	Relationship between reinforcing belt longitudinal center line direction and Kc		Warp direction	Warp direction	Warp direction	Bias intersection	Bias intersection	Bias intersection	Bias intersection
Burst strength (kg/cm^2 G)			1.0	1.1	1.0	1.2	1.2	1.1	1.0
General evolution			Bad	Bad	Bad	Bad	Bad	Bad	Bad

Example 8

A reinforcing belt-provided air bag was produced by the same procedures as in Comparative Example 2, except that a reinforcing cloth formed from a non-coated nylon 66 woven fabric was placed on an inside

face of each of the top cloth and the bottom cloth, and seam-joined to each of the top and bottom cloths while adjusting each of ϕa and ϕb values to 300 mm ($\phi a/L = \phi b/L = 0.86$), and a belt catcher was placed on and seam-joined to the reinforcing cloth.

The resultant air bag had a burst strength of 2.2 kg/cm^2 G and its general evaluation result was "good".

Example 9

A reinforcing belt-provided air bag was produced by the same procedures as in Example 6, except that a top reinforcing cloth formed from a non-coated polyester woven fabric was placed on an inside face of the top cloth, and seam-joined to the top cloth by adjusting ϕa to 200 mm ($\phi a/L = 0.74$). Also, the same reinforcing cloth-forming woven fabric as in Example 6 was used for the belt catchers. The resultant air bag exhibited a burst strength of 2.0 kg/cm^2 G and its general evaluation result was "good".

Example 10

An air bag was produced by the same procedures as in Comparative Example 3 except that a bottom reinforcing cloth formed from a non-coated polyester woven fabric was placed on an inside face of the bottom cloth and seam-joined to the bottom cloth while adjusting the ϕb to 500 mm ($\phi b/L = 1.43$). Then, the same woven fabric as that used for the bottom reinforcing cloth in Comparative Example 3 was used for the belt catchers. The resultant air bag had a burst strength of 1.8 kg/cm^2 G and its general evaluation result was "good".

[Industrial Applicability]

In accordance with the present invention, an air bag having an excellent burst strength and a high degree of safety for occupants when inflated can be provided.

Claims

1. An air bag provided with reinforcing belts, comprising:

a substantially circular top cloth formed from a woven fabric;

a substantially circular bottom cloth formed from a woven fabric, superimposed on and seam-joined to the circular top cloth at the circular circumferential edge portions thereof, and having a circular hole formed in the center portion of the bottom cloth, through which hole an inflator can be joined to the air bag;

a top reinforcing cloth located in and seam-joined to the center portion of the circular top cloth and comprising at least one woven fabric piece;

a bottom reinforcing cloth located on and seam-joined to a portion around the inflator-joining circular hole of the circular bottom cloth, and comprising at least one woven fabric piece; and

a plurality of reinforcing belts arranged on the inside face of the circular top cloth and on the inside face of the circular bottom cloth and each comprising at least one woven fabric piece,

characterized in that:

an end portion of each of the reinforcing belts is connected to one of the top reinforcing cloth and a top belt catcher seam-joined to the top cloth and comprising at least one woven fabric piece, and an opposite end portion of each of the reinforcing belts is connected to one of the bottom reinforcing cloth and a bottom belt catcher seam-joined to the bottom cloth and comprising at least one woven fabric piece;

the top and bottom reinforcing cloths or the top and bottom reinforcing cloths and the top and bottom belt catchers are respectively seam-joined to portions around the centers of the top and bottom cloths by a plurality of concentrically closed seam lines;

a outermost circumferential closed seam line of at least one of the top reinforcing cloth and bottom reinforcing cloth and each of the reinforcing belts satisfy the relationship (I);

$0.45 \leq \phi/L \leq 2.95$ (I)

wherein, ϕ represents a shortest straight line distance between two points at which a straight line drawn through a center of at least one of the circular top and bottom cloths having the closed outermost circumferential seam line, intersects the closed outermost circumferential seam line, and L represents a

straight line distance between an intersecting point of a longitudinal center line of the reinforcing belt with the closed outermost circumferential seam line of the top reinforcing cloth and an intersecting point of the longitudinal center line of the reinforcing belt with the closed outermost circumferential seam line of the bottom reinforcing cloth, measured along the longitudinal center line.

2. The air bag as claimed in claim 1, wherein in the relationship (I), the straight line distance represented by ϕ is in the range of from 130 to 550 mm.

3. The air bag as claimed in claim 1, wherein the relationship (I), the distance represented by L is in the range of from 160 to 360 mm.

4. The air bag as claimed in claim 1, wherein the longitudinal center line of the reinforcing belt extends in a direction intersecting, at a bias angle, both a warp direction and a weft direction of the woven fabric piece from which the reinforcing belt is formed.

5. The air bag as claimed in claim 1, wherein each of the reinforcing belts is connected, at each end portion thereof, to the top reinforcing cloth and to the bottom reinforcing cloth.

6. The air bag as claimed in claim 5, wherein the top reinforcing cloth and the bottom reinforcing cloth are in a substantially circular form.

7. The air bag as claimed in claim 5, wherein the top reinforcing cloth and the bottom reinforcing cloth are in a substantially polygonal form.

8. The air bag as claimed in claim 5, wherein a warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to a warp direction of the woven fabric piece from which the top reinforcing cloth is formed, and a warp direction of the woven fabric piece from which the circular bottom cloth is formed, intersects, at a bias angle, a warp direction of the woven fabric piece from which the bottom reinforcing cloth is formed.

9. The air bag as claimed in claim 5, wherein a warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to a warp direction of the woven fabric piece from which the reinforcing belt is formed, and a warp direction of the woven fabric piece, from which the circular bottom cloth is formed, intersects, at a bias angle, a warp direction of the woven fabric piece from which the reinforcing belt is formed.

10. The air bag as claimed in claim 5, wherein a warp direction of each of the top reinforcing cloth and the bottom reinforcing cloth intersects the longitudinal center line direction of the reinforcing belt connected to each of the top and bottom reinforcing cloths, at a bias angle.

11. The air bag as claimed in claim 5, wherein a longitudinal center line direction of the reinforcing belt intersects, at a bias angle, the warp and weft directions of the woven fabric piece from which the reinforcing belt is formed,

a warp direction of the woven fabric from which the circular bottom cloth is formed, intersects, at a bias angle, a warp direction of the woven fabric piece from which the bottom reinforcing cloth is formed, and the warp direction of the woven fabric piece from which the bottom reinforcing cloth is formed is parallel to the warp direction of the woven fabric piece from which the reinforcing belt is formed.

12. The air bag as claimed in claim 5, wherein the top reinforcing cloth and belts located on the circular top cloth are formed from one and the same woven fabric piece, the bottom reinforcing cloth and belts located on the circular bottom cloth are formed from one and the same woven fabric piece, and the reinforcing belt on the circular top cloth is seam-joined to the corresponding reinforcing belt on the circular bottom cloth.

13. The air bag as claimed in claim 12, wherein the warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to the warp direction of the woven fabric piece from which the top reinforcing cloth is formed, and the warp direction of the woven fabric piece from which the circular

bottom cloth is formed intersects, at a bias angle, the warp direction of the woven fabric piece from which the bottom reinforcing cloth is formed.

14. The air bag as claimed in claim 1, wherein the closed outermost circumferential seam line is in a substantially circular form.

15. The air bag as claimed in claim 1, wherein the closed outermost circumferential seam line is in a substantially regular square form.

16. The air bag as claimed in claim 15, wherein each side of the regular square is at a right angle to the longitudinal center line direction of a reinforcing belt corresponding to the side.

17. The air bag as claimed in claim 1, wherein the circular top and bottom cloths are formed from a non-coated woven fabric, and yarns from which the non-coated woven fabric is formed have a thickness of 150 to 550 deniers.

18. The air bag as claimed in claim 1, wherein the top reinforcing cloth and top belt catcher are formed from a non-coated woven fabric, the bottom reinforcing cloth and bottom belt catcher are formed from a coated woven fabric, and the non-coated woven fabric and the coated woven fabric comprises yarns having a thickness of 150 to 550 deniers.

19. The air bag as claimed in claim 1, wherein the reinforcing belts are formed from a non-coated woven fabric.

20. The air bag as claimed in claim 1, wherein each of the circular top and bottom cloths, the top and bottom reinforcing cloths, the top and bottom belt catchers and the reinforcing belts are formed from a polyester fiber woven fabric.

21. The air bag as claimed in claim 1, wherein both end portions of each of the reinforcing belts are respectively connected to the top belt catcher and to the bottom belt catcher.

22. The air bag as claimed in claim 21, wherein the top and bottom belt catchers are respectively in a substantially circular form.

23. The air bag as claimed in claim 21, wherein the top and bottom belt catchers are respectively in a polygonal form.

24. The air bag as claimed in claim 21, wherein the warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to the warp direction of the woven fabric piece from which the top belt catcher is formed, and the warp direction of the woven fabric piece from which the circular bottom cloth is formed intersects, at a bias angle, the warp direction of the woven fabric piece from which the bottom belt catcher is formed.

25. The air bag as claimed in claim 21, wherein the warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to the warp direction of the woven fabric piece from which the reinforcing belt is formed, and the warp direction of the woven fabric piece from which the circular bottom cloth is formed intersects, at a bias angle, the warp direction of the woven fabric piece from which the reinforcing belt is formed.

26. The air bag as claimed in claim 21, wherein the warp direction of the woven fabric piece from which one of the top and bottom belt catchers is formed intersects, at a bias angle, the longitudinal center line direction of the reinforcing belt connected to the one of the top and bottom belt catchers.

27. The air bag as claimed in claim 21, wherein the longitudinal center line direction of the reinforcing belt intersects, at a bias angle, the warp and weft directions of the woven fabric piece from which the reinforcing belt is formed, the warp directions of the woven fabric pieces from which the circular top cloth, and the reinforcing belt and the top reinforcing cloth located on the circular top cloth are respectively formed, are parallel to each other, the warp direction of the woven fabric piece from which

the circular bottom cloth is formed intersect, at a bias angle, the warp direction of the woven fabric piece from which the bottom belt catcher is formed, and the warp directions of the woven fabric pieces from which the bottom belt catcher and the reinforcing belt are respectively formed are parallel to each other.

28. The air bag as claimed in claim 21, wherein the top belt catcher and the reinforcing belts located on the circular top cloth are formed from one and the same woven fabric piece, the bottom belt catcher and the reinforcing belts located on the circular bottom cloth are formed from one and the same woven fabric piece, and the reinforcing belts located on the circular top cloth are respectively seam-joined to the corresponding reinforcing belts located on the circular bottom cloth.

29. The air bag as claimed in claim 28, wherein the warp direction of the woven fabric piece from which the circular top cloth is formed is parallel to the warp direction of the woven fabric piece from which the top belt catcher is formed and the warp direction of the woven fabric piece from which the circular bottom cloth is formed, intersects, at a bias angle, the warp direction of the woven fabric piece from which the bottom belt catcher is formed.

30. The air bag as claimed in claim 1, wherein the bottom cloth and the inflator-joining circular hole satisfy the relationship (II):

$$32 \leq (\phi k - \phi c)/2 \leq 123 \qquad \text{(II)}$$

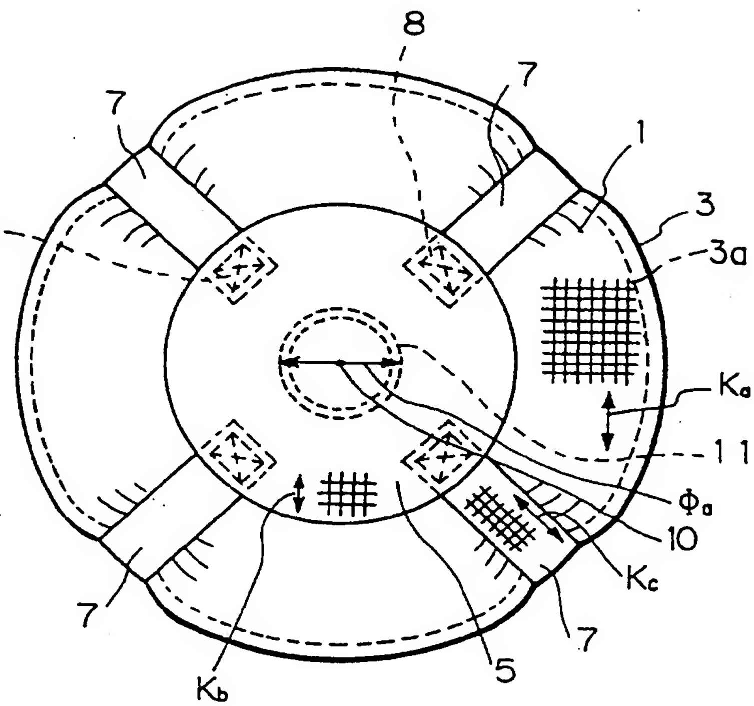
wherein ϕk represents a shortest straight line distance in mm between two points at which a straight line drawn in parallel to one of the warp and weft directions of the circular bottom cloth-forming woven fabric piece in which one direction the woven fabric piece exhibits a tensile strength lower than in the other direction, intersects the outermost circumferential closed seam line, and ϕc represents a diameter in mm of the inflator-joining circular hole.

31. The air bag as claimed in claim 1, wherein the closed outermost circumferential seam lines of the top and bottom reinforcing clothes have a stitching pitch $P\phi$ of 1.0 to 2.5 mm.

32. The air bag as claimed in claim 1, wherein the warp direction of the woven fabric piece from which the top cloth is formed intersects, at a bias angle, the warp direction of the woven fabric piece from which the bottom cloth is formed.

33. The air bag as claimed in claim 32, wherein the intersection is at an angle of 40 to 50 degrees.

Fig. 1A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Kb

Fig. 1B

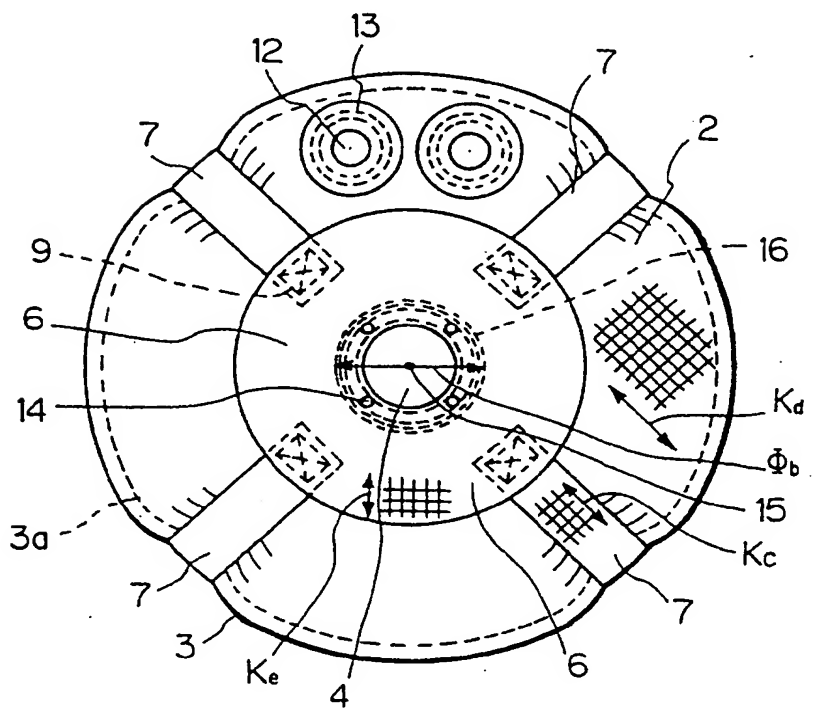
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Fig. 1C

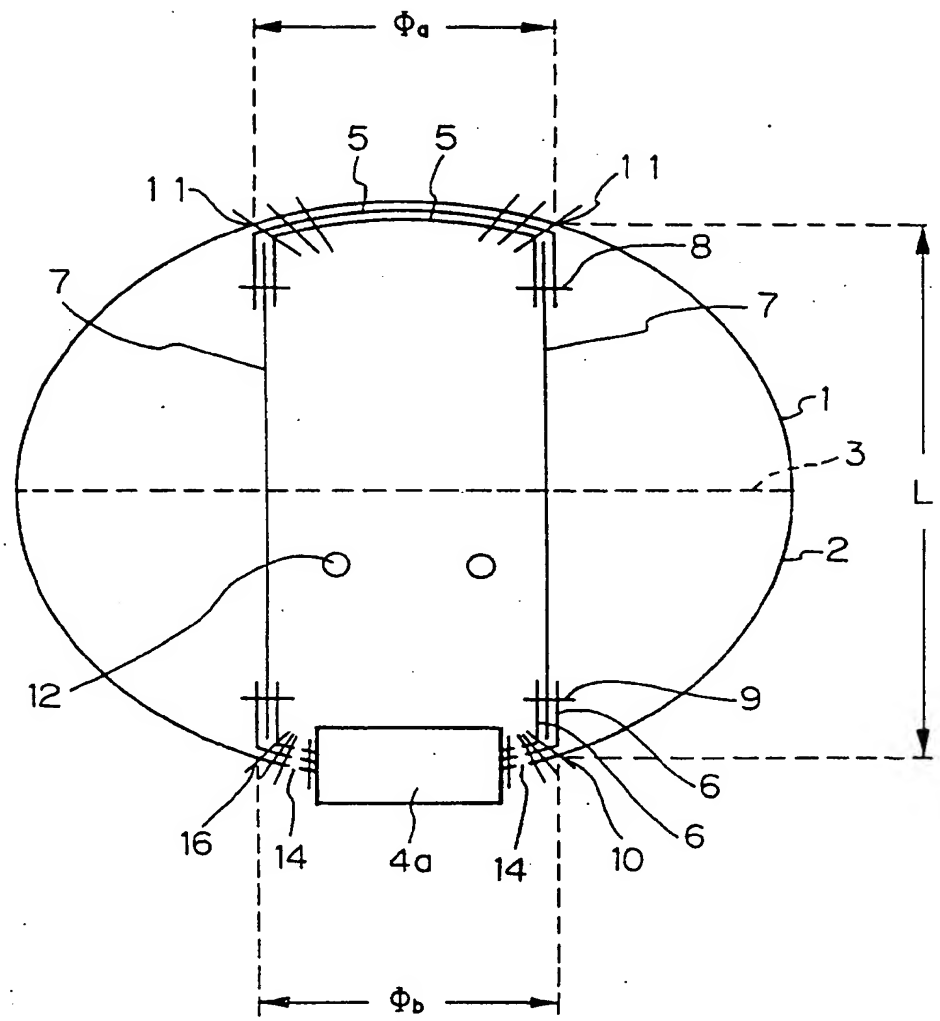

Fig. 2A

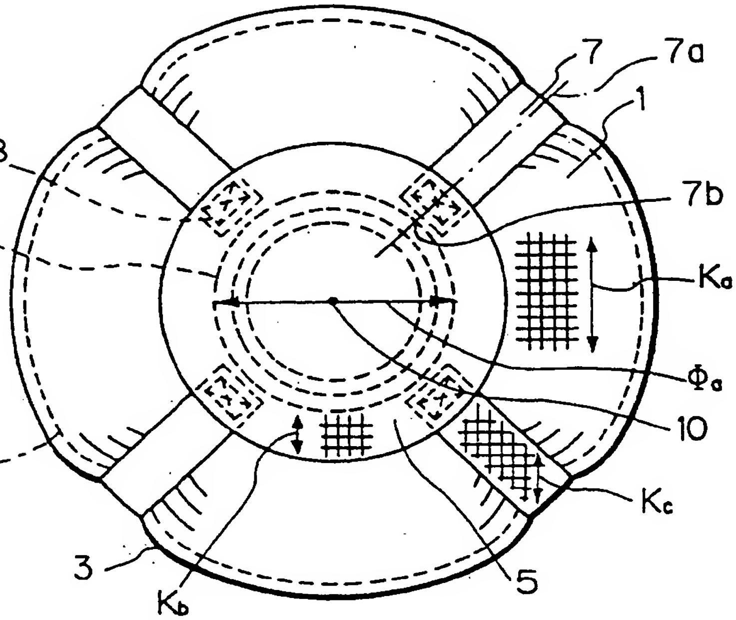
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Fig. 2B

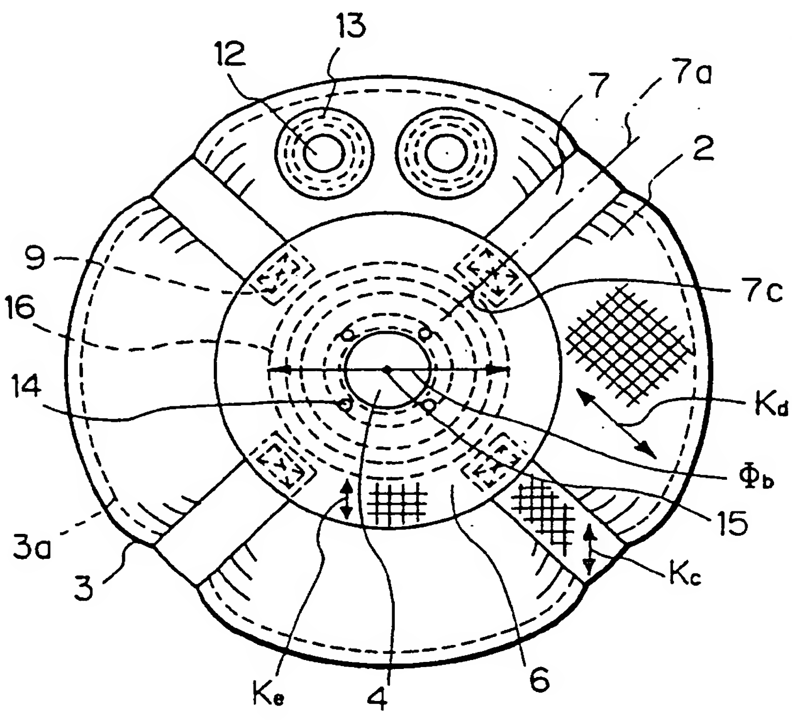
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Fig. 2C

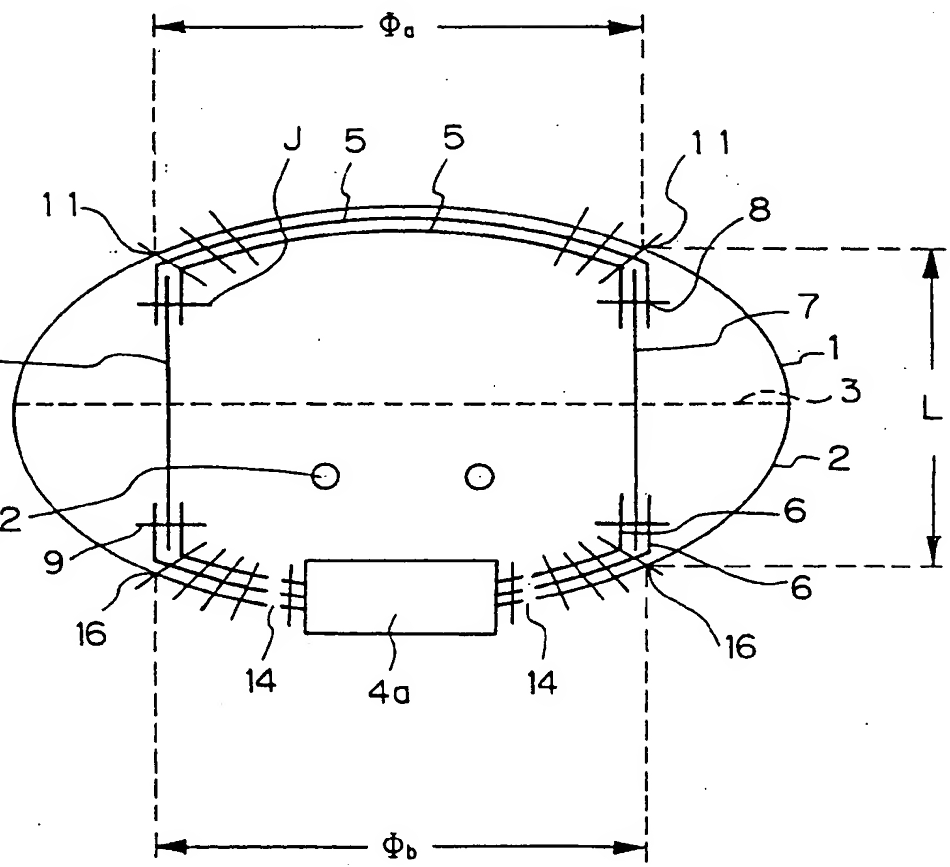

Fig. 3A

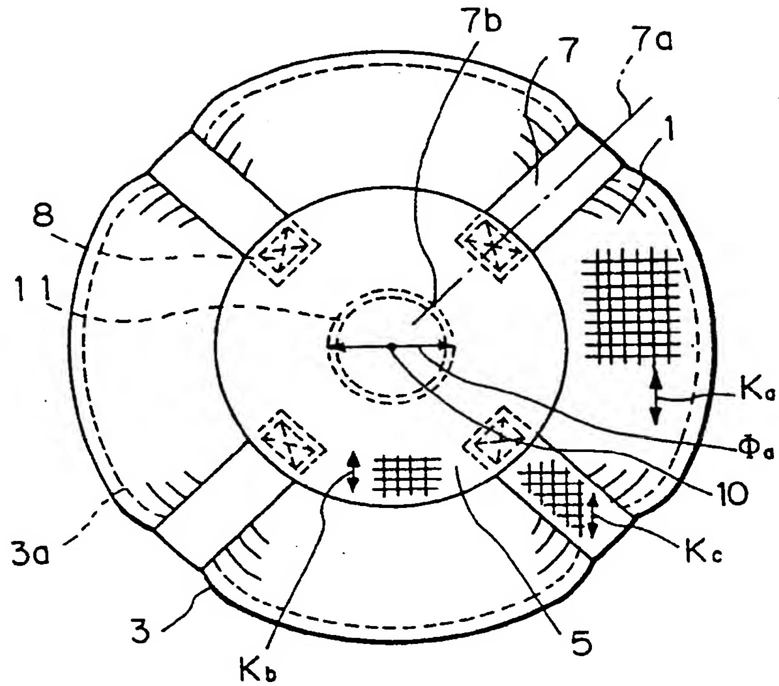
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Fig. 3B

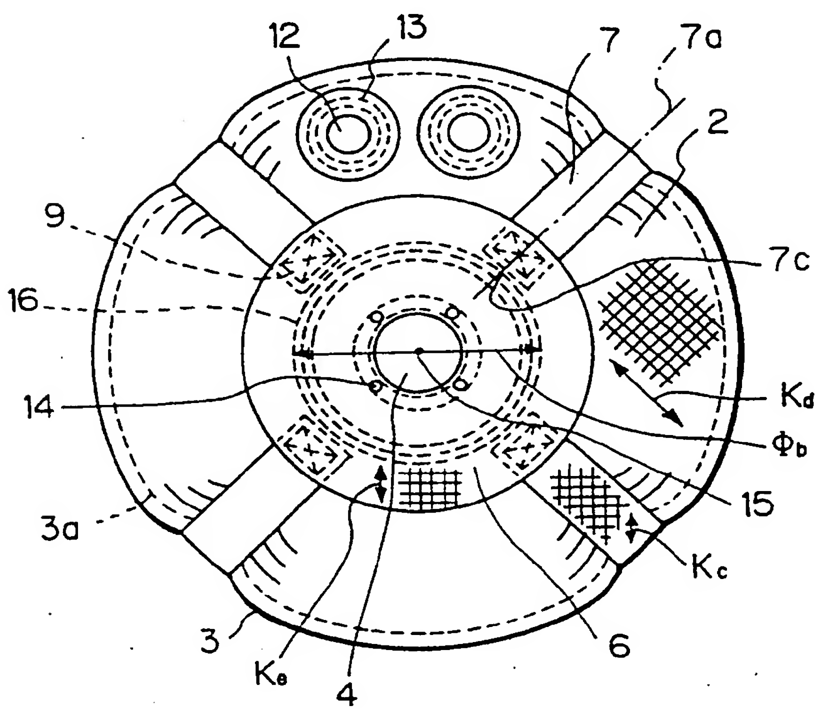
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Fig. 3C

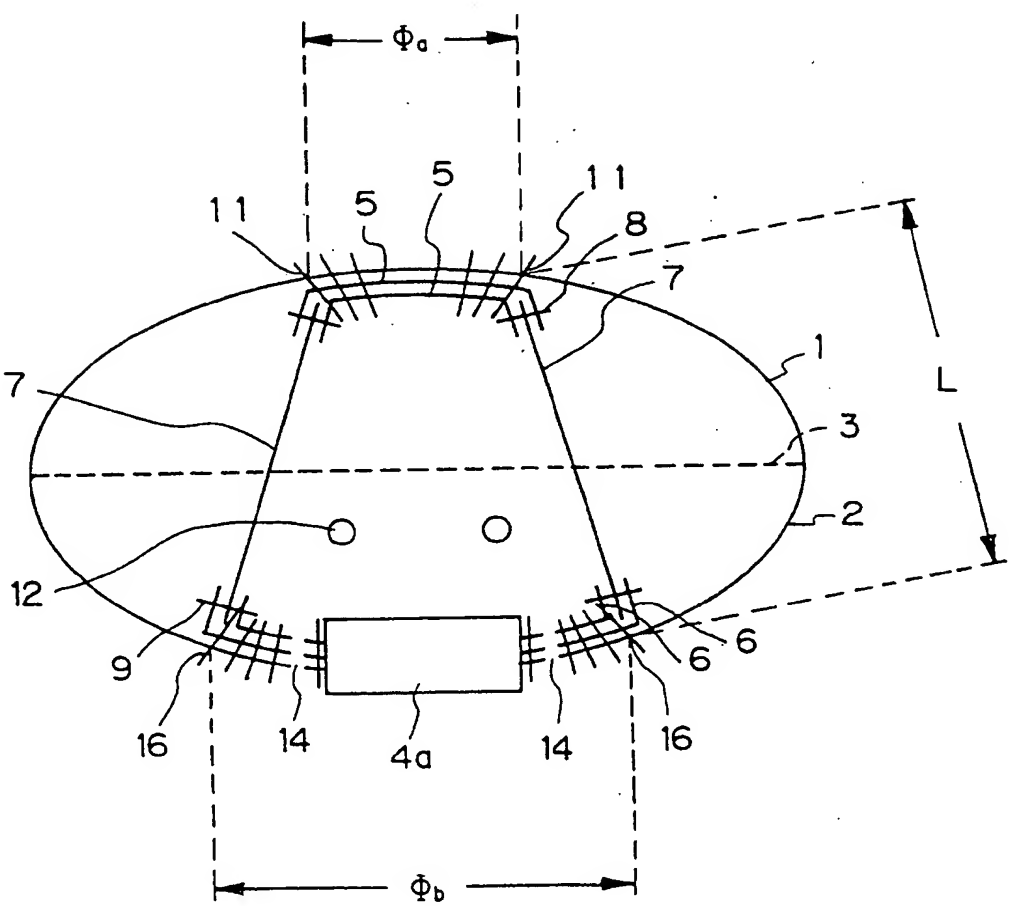

Fig. 4A

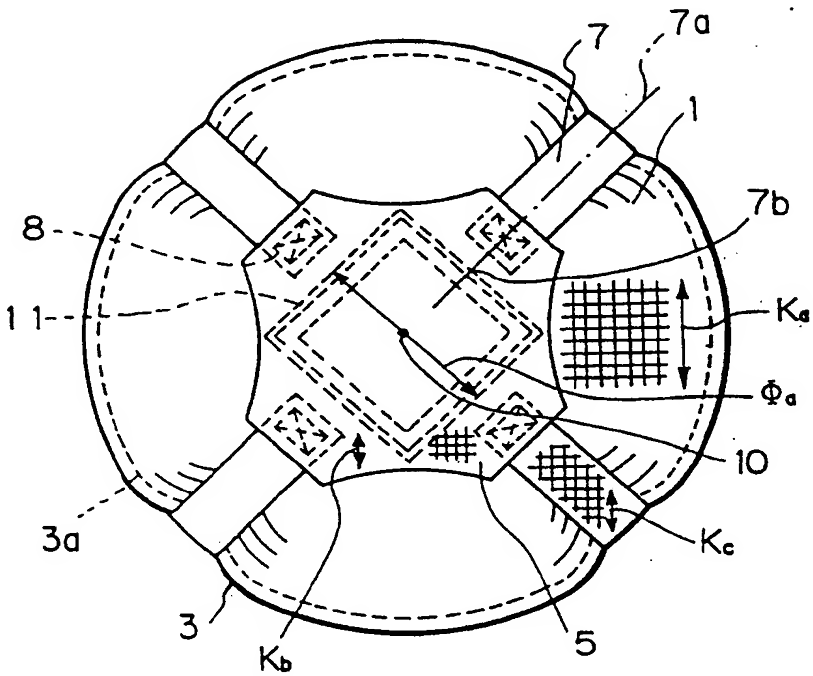
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Fig. 4B

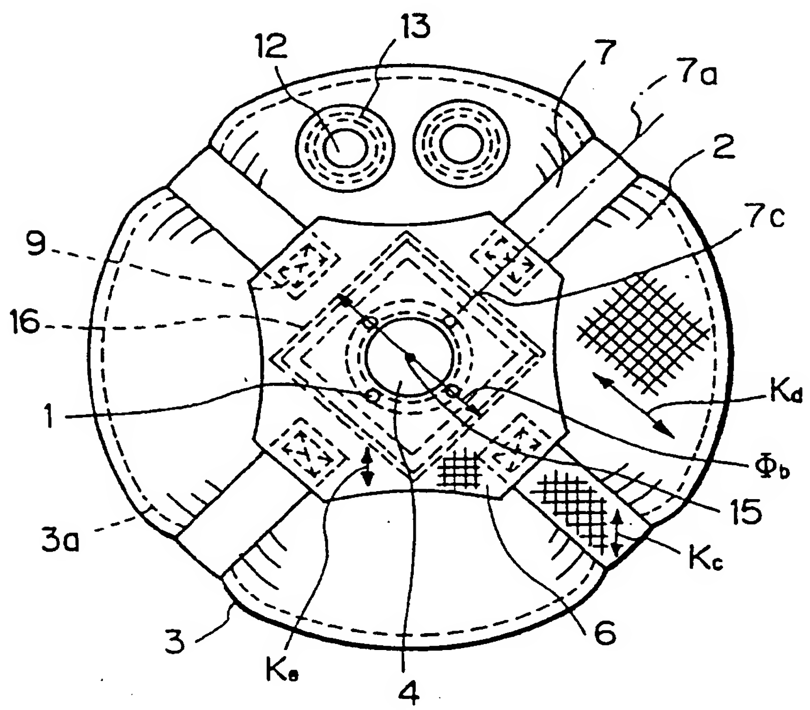
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Fig. 5A

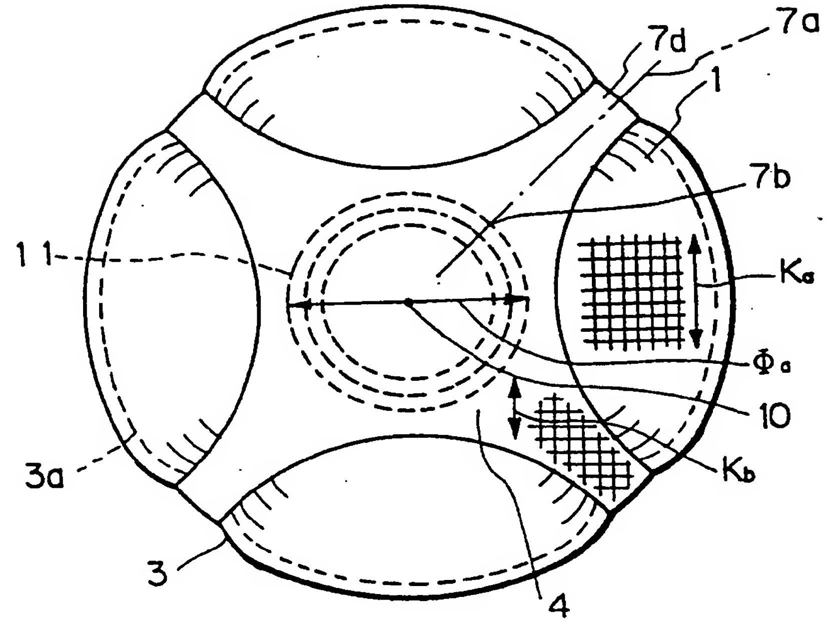


Fig. 5B

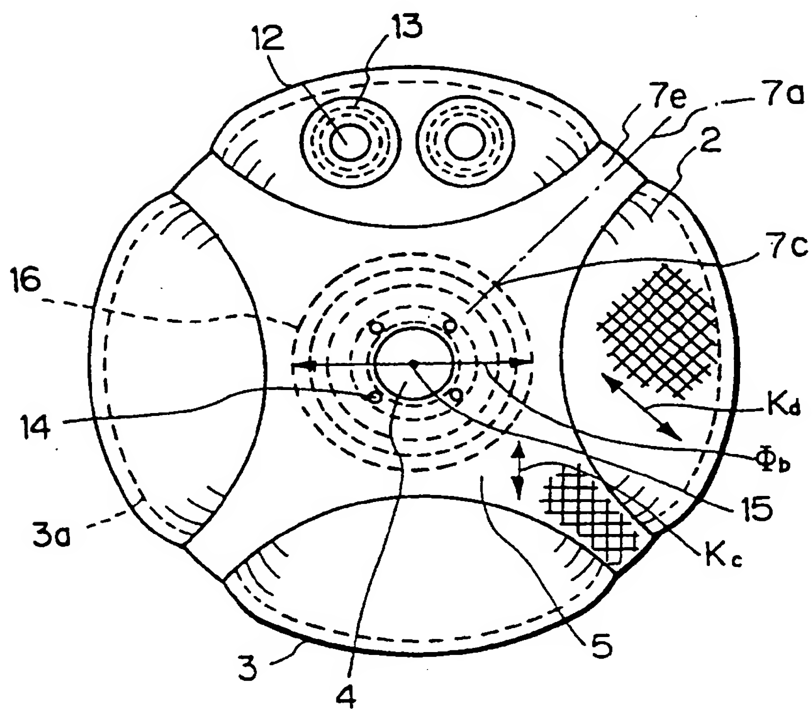


Fig. 5C

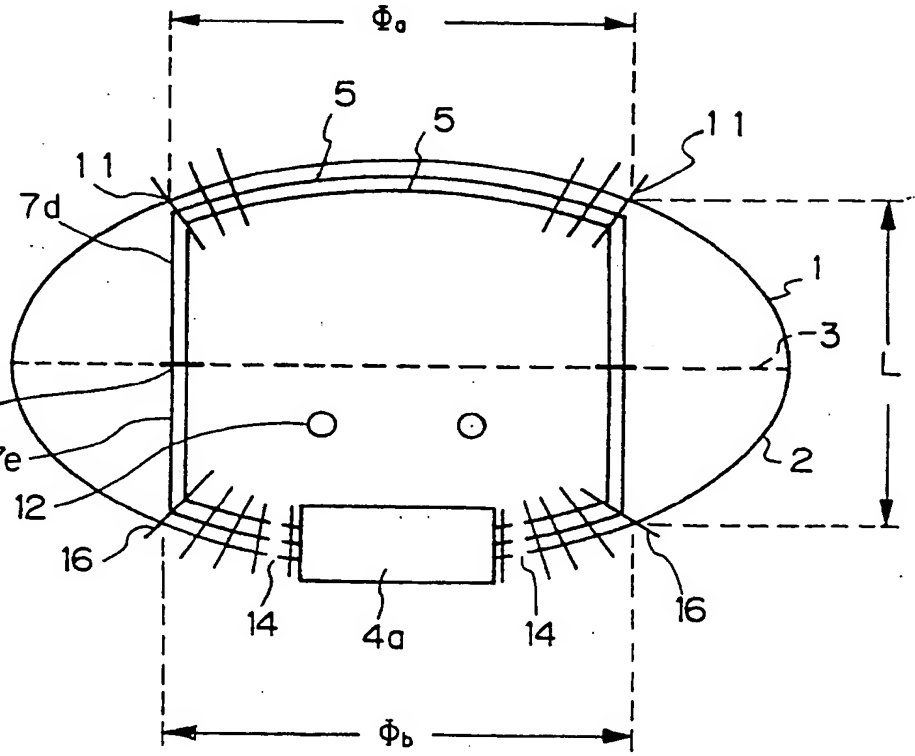


Fig. 6A

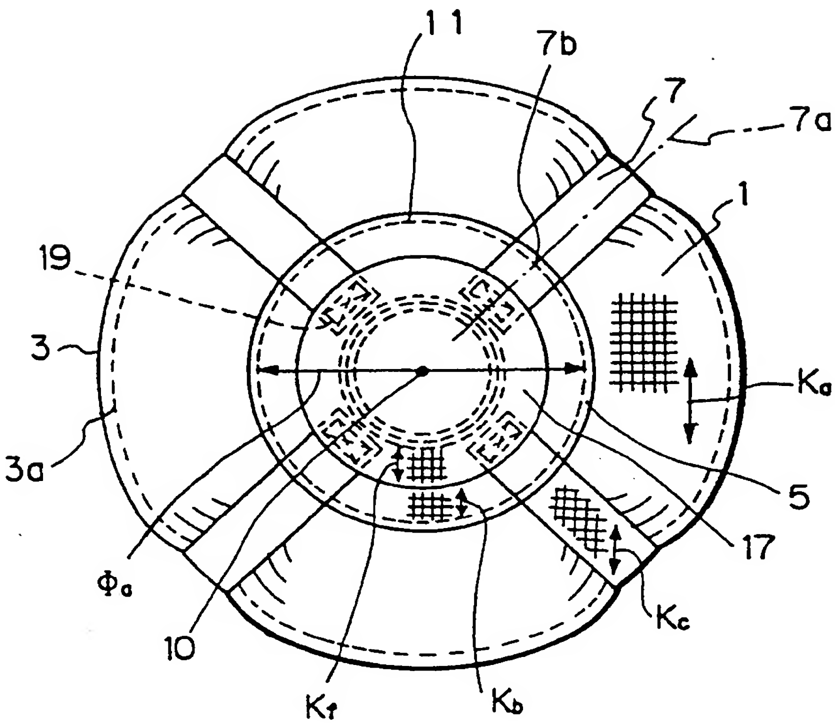


Fig. 6B

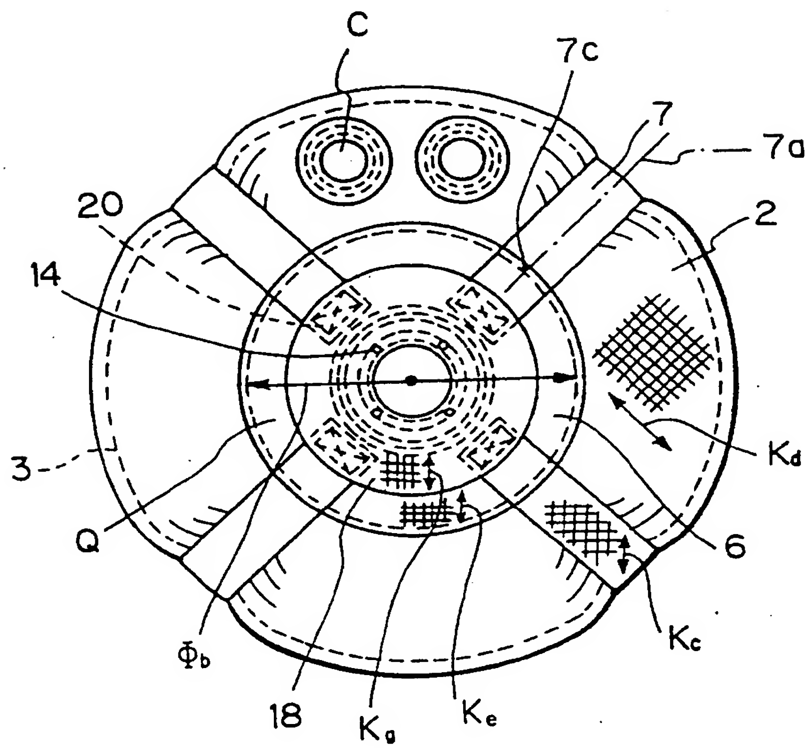
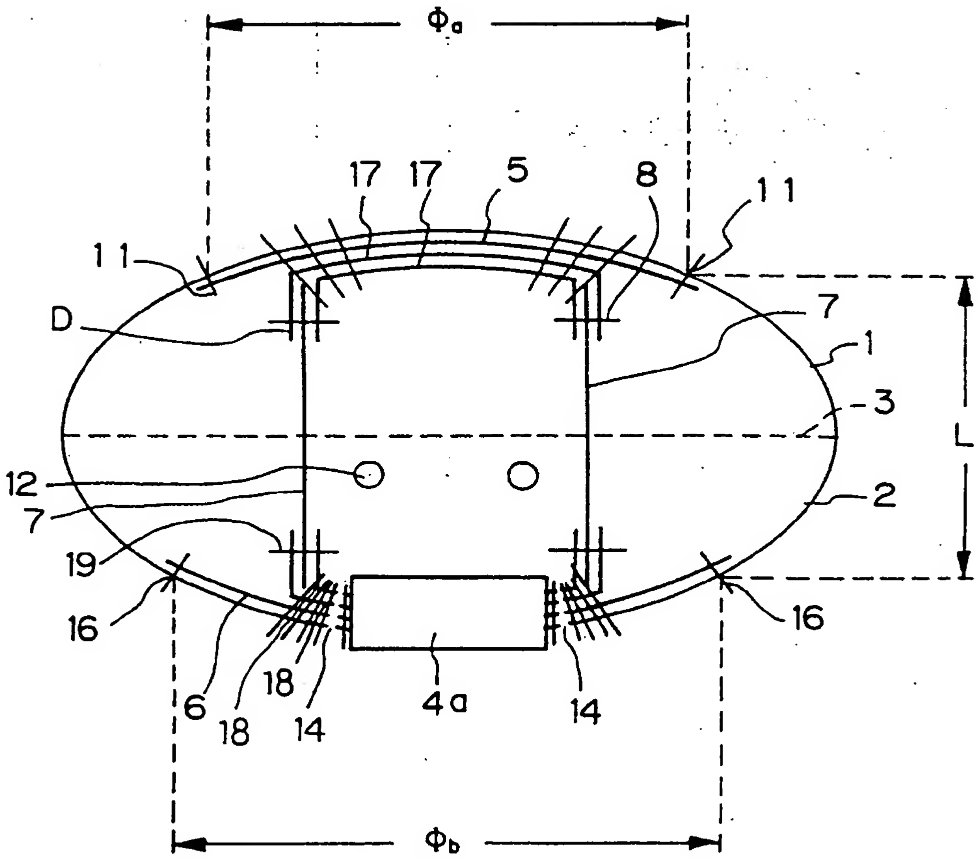


Fig. 6C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP93/01315

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^5 B60R21/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^5 B60R21/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1993
Kokai Jitsuyo Shinan Koho 1971 - 1993

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, A, 2-74439 (Achilles Corp.), March 14, 1990 (14. 03. 90), (Family: none)	1-33
A	JP, A, 1-122750 (Asahi Chemical Industry Co., Ltd.), May 16, 1989 (16. 05. 89), (Family: none)	1-33
A	JP, A, 64-90842 (Takata Corp.), April 7, 1989 (07. 04. 89), (Family: none)	1-33
A	JP, A, 64-90841 (Takata Corp.), April 7, 1989 (07. 04. 89), (Family: none)	1-33

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
December 14, 1993 (14. 12. 93)	December 21, 1993 (21. 12. 93)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)